

^{48}Ca $2\beta^-$ decay **1996Ba80,2000Br63,2000OgZW**

Type	Author	History Citation	Literature Cutoff Date
Full Evaluation	T. W. Burrows	NDS 107, 1747 (2006)	14-Apr-2006

Parent: ^{48}Ca : $E=0.0$; $J^\pi=0^+$; $T_{1/2}=1.9\times 10^{19}$ y $+45-8$; $Q(2\beta^-)=4274$ 4; $\%2\beta^-$ decay= 7×10^1 3

$^{48}\text{Ca}-T_{1/2}$: From ^{48}Ca Adopted Levels. $T_{1/2}(2\beta^-)=2.5\times 10^{19}$ $+39-10$ estimated by evaluator from partial $T_{1/2}(2\beta^-)$'s to g.s., 984, 2421, and 2997. Other: $T_{1/2}(2\nu 2\beta^-)=2.87\times 10^{19}$ y 51 (2004Ra26; from analysis of Gamow-Teller strengths in $^{48}\text{Ti}(\text{d},2\text{p})$ and $^{48}\text{Ca}(\text{p},\text{n})$.) and 3.55×10^{19} y 75 (2006Fr03, preliminary; from analysis of Gamow-Teller strengths in $^{48}\text{Ti}(\text{d},2\text{p})$ and $^{48}\text{Ca}(^3\text{He},\text{t})$).

$^{48}\text{Ca}-Q(2\beta^-)$: From 2003Au03.

$^{48}\text{Ca}-\%2\beta^-$ decay: 75% $+25-38$ from ^{48}Ca Adopted Levels.

1970Ba61 measured $I(2\beta^-)$. 10.6-grams $^{48}\text{CaF}_2$ source in a deep salt mine; streamer chamber. Data were reanalyzed by 1989Ba05.

1986Al05 reanalyzed the ^{48}Ca β^- decay data of 1985Al17 to obtain a lower limit on $T_{1/2}$ for ^{48}Ca 0^+ to ^{48}Ti $2297,2^+$ $2\beta^-$ decay transition. The 2014γ -983 γ coincidence would be the signature for this decay.

1991SaZQ measured $I(2\beta^-)$. Natural CaF_2 crystals containing a total of 0.32 grams of ^{48}Ca in Kamioka underground laboratory; 1314 hours.

1991Yo05 measured $I(2\beta^-)$. Natural CaF_2 crystals containing a total of 43.0 grams of ^{48}Ca in coal mine; 7588.5 hours.

1996Ba80,1996Bb01: measured $1e^-$ and $2e^-$; tunnel at Hoover Dam under a minimum of 72 meters of rock; UC Irvine time projection chamber with $2\beta^-$ source as the central electrode in a magnetic field. 42.2 g of CaO_3 (18.5 mg/cm² total thickness with substrate and binder) and 10.3 CaO_3 (5.4 mg/cm²) sources enriched to 73% ^{48}Ca . 2440 h exposure for thick source and 4001 h exposure for thin source. 14.0 ± 4.7 $2\beta^-$ events from one analysis of the thin source data resulted in $T_{1/2}(2\nu 2\beta^-)=4.3\times 10^{19}$ y $+24-11$ with systematic uncertainty of 1.4×10^{19} y based on the difference between two different analyses of the thin source and detector efficiency. See 1996Ba80 for more details on the analysis, results from the thick target, and an alternate but consistent with the one adopted by 1996Ba80.

2002Ba33: searched for ^{48}Ca β^- and $2\beta^-$ decay in a 63.86-GM powder of $^{48}\text{CaCO}_3$ (73% ^{48}Ca). Mondane Underground Laboratory. Measured γ 's with low-background 400 cm³ HPGe; passive shield of 6 cm lead, 10 cm of OFHC copper, and 15 cm of ordinary lead (free space minimized and shield enclosed in Al box flushed by nitrogen to reduce ^{222}Rn gas).

2000Br63,2000Br44: measured $\beta\beta$ -coincidences; Modane Underground Laboratory, TGV (Telescope Germanium Vertical; 16 HPGe detectors, 20-cm Cu thick shielding, airtight box), $\beta\gamma$ discrimination. 3.5 g 1 of ^{48}Ca sources in 8 squares with mixture of 80% CaCO_3 and 20% polyvinyl (77.8% ^{48}Ca); 8 similar squares with natural calcium for background estimates. 8700 h run. 5 events associated with $2\nu 2\beta^-$ decay of ^{48}Ca found in spectrum between 2.65 and 3.45 MeV resulting in $T_{1/2}(2\nu 2\beta^-)=4.2\times 10^{19}$ y $+33-13$ and an estimated $T_{1/2}(0\nu 2\beta^-)>1.5\times 10^{21}$ y (90% C.L.), $\langle m \rangle_\nu < 20.9$ eV. 23 ± 16 events for $E>2$ MeV resulting in $T_{1/2}(2\nu 2\beta^-)=4.0\times 10^{19}$ y $+92-16$.

2000OgZW,2000OgZX: measured $I(\beta^-)$; Oto Cosmo Laboratory, ELEGANT VI (CaF_2 scintillators surrounded by active and passive shields with "delayed- α SYSTEM"). 2589.3 h run. 2 events associated with $0\nu 2\beta^-$ decay of ^{48}Ca resulting in preliminary $T_{1/2}(0\nu 2\beta^-)\geq 2.0\times 10^{22}$ y.

2005Zd02: pilot study on use of enriched $^{48}\text{CaWO}_4$ crystal scintillators to measure ^{48}Ca $T_{1/2}(0\nu 2\beta^-)$. Scintillation properties (energy resolution, α/β ratio, and pulse-shape discrimination ability) and radiopurity of $^{48}\text{CaWO}_4$ scintillators studied. Preliminary result using a small non-enriched crystal was $T_{1/2}(0\nu 2\beta^-)>6\times 10^{19}$ y for a 1374 h measuring time. Estimated sensitivity for ≈ 100 kG $^{48}\text{CaWO}_4$ crystals is $T_{1/2}(0\nu 2\beta^-)>1.0\times 10^{27}$ y.

^{48}Ca is a particularly attractive candidate for a $2\beta^-$ -decay search. The β^- decay of ^{48}Ca to ^{48}Sc is suppressed due to the angular momentum conservation law ($J^\pi(^{48}\text{Ca}, \text{g.s.})=0^+$ and $J^\pi(^{48}\text{Sc}, \text{g.s.})=6^+$) and the $2\beta^-$ decay has the largest available energy release for all $2\beta^-$ candidates ($Q(2\beta^-)=4.274$ MeV 4) that is higher than most of the radioactive backgrounds. Therefore, the large space factor compensates for a relatively small nuclear matrix element. See 1993Mo36 for a review of $2\beta^-$ decay searches. Others: see the Nuclear Science References File for theoretical studies, compilations, and reviews. See 1990Al19 for a measurement of $\sigma(\theta)$ from the $^{48}\text{Ti}(\text{n},\text{p})$ reaction at $E=198$ MeV and its possible implications on ^{48}Ca $2\beta^-$ decay.

Others: see also 1985Al14. See the Nuclear Science References File for theoretical studies, compilations, and reviews. See 1990Al19 for a measurement of $\sigma(\theta)$ from the $^{48}\text{Ti}(\text{n},\text{p})$ reaction at $E=198$ MeV and its possible implications on ^{48}Ca $2\beta^-$ decay.

$^{48}\text{Ca } 2\beta^-$ decay 1996Ba80,2000Br63,2000OgZW (continued) ^{48}Ti Levels

<u>E(level)[†]</u>	<u>J^π[†]</u>	<u>T_{1/2}[†]</u>	Comments
0.0	0 ⁺	stable	T _{1/2} (2ν2β ⁻)=4.2×10 ¹⁹ y +22-11 from 2006BaZZ based on a weighted av of 4.3×10 ¹⁹ y +24-11 (1996Ba80. Syst ΔT _{1/2} =1.4×10 ¹⁹ y) and 4.2×10 ¹⁹ y +33-13 (2000Br63) for decay to this state; syst ΔT _{1/2} from 1996Ba80 added in quadrature before averaging. Other: >3.6×10 ¹⁹ y (1970Ba61). Theory: 1.3×10 ¹⁹ y ≤ T _{1/2} (2ν2β ⁻) ≤ 6.0×10 ¹⁹ y (1998Su19). T _{1/2} (0ν2β ⁻) ≥ 1.4×10 ²² y for decay to this state (2004Og01; 90% C.L.). Others: >1.5×10 ²¹ y (2000Br63. 90% C.L.), >1.1×10 ²¹ y (1989Ba05), >9.5×10 ²¹ y (1991Yo05. 76% C.L.), and >1.6×10 ¹⁹ y (1991SaZQ). Theory: 1.3×10 ²⁵ y ≤ T _{1/2} (0ν2β ⁻) ≤ 4.0×10 ²⁵ y (1998Su19).
(983.5390 24)	2 ⁺		T _{1/2} (2β ⁻) > 4.7×10 ¹⁹ y for decay to this state (2002Ba33. 90% C.L.). Other: T _{1/2} (0ν2β ⁻) > 1.0×10 ²¹ y (1970Ba61). Theory: T _{1/2} (2ν2β ⁻) = 5.0×10 ²⁶ y (1984Ha60).
(2421.059 11)	2 ⁺		T _{1/2} (2β ⁻) > 11×10 ¹⁹ y for decay to this state (2002Ba33. 90% C.L.). Theory: T _{1/2} (2ν2β ⁻) = 3.6×10 ²⁶ y (1984Ha60).
(2997.22 16)	0 ⁺		T _{1/2} (2β ⁻) > 9.0×10 ¹⁹ y for decay to this state (2002Ba33. 90% C.L.). Other: T _{1/2} (0ν2β ⁻) > 8×10 ¹⁸ y (1986Al05. 95% C.L.).

[†] From the Adopted Levels.γ(^{48}Ti)

<u>E_γ[†]</u>	<u>E_i(level)</u>	<u>J_i^π</u>	<u>E_f</u>	<u>J_f^π</u>
(983.5299 24)	(983.5390)	2 ⁺	0.0	0 ⁺
(2013.66 16)	(2997.22)	0 ⁺	983.5390?	2 ⁺

[†] From the Adopted Gammas.

Legend

 $^{48}\text{Ca } 2\beta^-$ decay 1996Ba80,2000Br63,2000OgZWDecay Scheme

- > γ Decay (Uncertain)
 ● Coincidence
 ○ Coincidence (Uncertain)

